UCRL-JC-121119
PREPRINT

A Sodium Guide Star Laser System for the Lick Observatory 3 Meter Telescope

H. W. Friedman, G. V. Erbert, D. T. Gavel,
T. C. Kuklo, J. G. Malik, J. T. Salmon, D. A. Smauley,
G. R. Thompson, and J. N. Wong

This paper was prepared for submittal to the
OSA Adaptive Optics '95
Garching, Germany
October 2-6, 1995

May 25, 1995

Lawrence Livermore National Laboratory

ABSTRACT

A Sodium Guide Star Laser System for the Lick Observatory 3 Meter Telescope

Herbert W. Friedman, Gaylen V. Erbert, Donald T. Gavel,
Thomas C. Kuklo, Jody G. Malik, J. Thaddeus Salmon,
David A. Smauley, Gary R. Thompson, and Jen Nan Wong

Lawrence Livermore National Laboratory, Box 808, Livermore, CA 94550

Telephone: 510-422-2257

Fax: 510-422-1413

The design, installation and performance data of a 20 W pulsed laser system for the 3 meter Shane telescope at the Lick Observatory is presented.

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

A Sodium Guide Star Laser System for the Lick Observatory 3 Meter Telescope

Herbert W. Friedman, Gaylen V. Erbert, Donald T. Gavel,
Thomas C. Kuklo, Jody G. Malik, J. Thaddeus Salmon,
David A. Smauley, Gary R. Thompson, and Jen Nan Wong

Lawrence Livermore National Laboratory, Box 808, Livermore, CA 94550

Telephone: 510-422-2257
Fax: 510-422-1413

The use of sodium-layer laser guide stars for adaptive optics systems greatly enhances the sky coverage as compared to systems using natural guide stars. In order to demonstrate the feasibility of a sodium-layer guide star, a 20 W pulsed dye laser system has been designed and installed on the 3 meter Shane telescope at the Lick Observatory, Mt. Hamilton, California. The adaptive optics system used in conjunction with the laser guide star system has been described elsewhere[1] and has already demonstrated diffraction limited images at the 2.2 micron wavelength using natural guide stars. The integration of the sodium laser guide star and the adaptive optics systems represents the first such installation on an astronomical telescope.

The 20 W power level from the laser system should correct images to a Strehl ratio of 0.5 at 2.2 microns according to models developed at LLNL and elsewhere. The pulse format of 150 ns wide pulses at 11.5 kHz results in a peak power irradiance at the sodium layer of about 4 W/cm^2 assuming a spot size in the mesosphere of 40 cm. The small spot size is achieved by a laser beam divergence of 1.5 times the diffraction limit and a laser launch telescope diameter of 30 cm. The modulation format of the laser has been designed to match the double peaked absorption profile of mesospheric sodium with the result that the saturation flux is about equal to the peak power irradiance. Higher average power lasers would require higher pulse repetition rates, longer pulse duration or both to maintain this relationship.

The laser system consists of a set of three frequency doubled YAG laser pumping a set of dye lasers to produce the output at the sodium wavelength of 0.589 microns. The YAG lasers are assembled at LLNL using commercial components and produce 65 W of green power at 0.532 microns using an intracavity KTP doubling crystal. CW flashlamps pump the Nd doped YAG laser rod and an acousto-optic Q switch produces the short pulse format. The input power for each YAG laser is approximately 8 kW. The YAG lasers pump a set of three liquid dye laser consisting of a Dye Master Oscillator (DMO), a preamplifier and a power amplifier. The DMO produces a narrow band, single (longitudinal and transverse) mode beam which is frequency stabilized using a opto-galvanic, low pressure sodium cell and then phase modulated using a pair of tuned circuit, electro-optic crystals. The laser power from this waveform generator is then increased to the 20 W level in a set of two amplifiers which are also pumped by the YAG laser. The output beam is expanded to 20 cm and launched to the sodium layer.

A unique feature of this laser system is the use of fiber optics to separate the high power, inefficient laser components from the efficient dye laser converters to remove sources of waste heat from the dome area. An additional benefit is that the dye laser converters are sufficiently small that they can be mounted directly on the telescope eliminating the need to pass the beam through the equatorial (or azimuth) and elevation bearings. The YAG pump lasers, DMO and support equipment are located in a room below the dome floor with a separate air conditioning system. Fiber optic cables transport the low power dye light and high power pump light to the preamplifier and power amplifier units which are located in a 2' x 4' enclosure at the base of the telescope, see Figure 1.

The beam control system is located in the middle of the telescope and the laser launch telescope is located at the end as shown in Figure 1. The beam control system consists of a "dog-leg" set of optics for Pointing and Centering (P&C), a high band width tilt mirror and a Hartmann wave front sensor. The sensor for the P&C closed loop control is after the last reflective optic and maintains the laser beam position and attitude. The signal for the high band width tilt mirror is derived from the adaptive optics system and therefore removes all jitter components including those from the laser, optics and the atmosphere in the uplink propagation path. The Hartmann sensor views the wave front of the laser beam both from the output of the laser amplifier and the output of the (refractive) launch telescope as measured by a retro reflection from the primary lens. The philosophy here is to diagnose as much of the laser as possible before launching the beam to reduce the dependency of the laser guide star system on mesospheric measurements.

The laser system has been installed on the Shane telescope and over 17 W have been measured during the first light propagation series. The process of bore sighting the laser launch telescope with the Shane telescope is underway and integrated experiments with the adaptive optics system are planned for the summer. The results of these observations will be presented.

References

1. "Adaptive Optics at Lick Observatory", J. M. Brase et al., SPIE 1994 Symposium on Astronomical Telescopes & Instrumentation for the 21st Century, Kona, HI, March 1994

Technical Information Department • **Lawrence Livermore National Laboratory**
University of California • Livermore, California 94551